Coupled Ocean-Wave-Atmosphere Modeling of a Cold Wake Producing Mediterranean Cyclone

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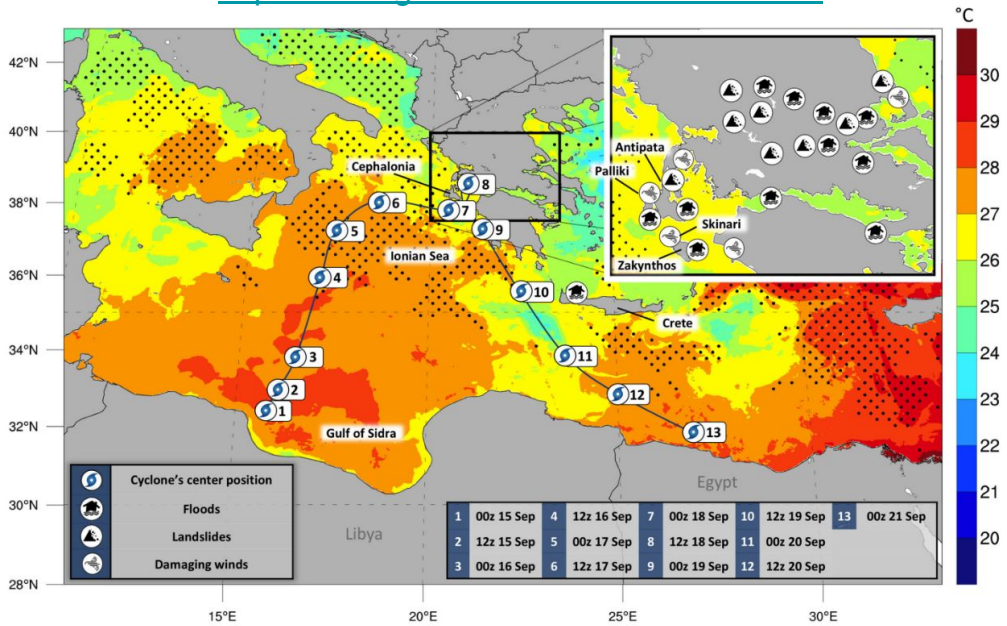
Medicane (Mediterranean hurricane) Ianos

Medicanes (no official definition)

Hybrid cyclone in the extratropics

- Presenting some characteristics of tropical cyclones (TCs)
- BUT smaller & shorter lived than TCs

Lagouvardos et al. (2022) BAMS
https://doi.org/10.1175/BAMS-D-20-0274.1



How close is Ianos to a tropical cyclone?
How do coupled processes impact Ianos?

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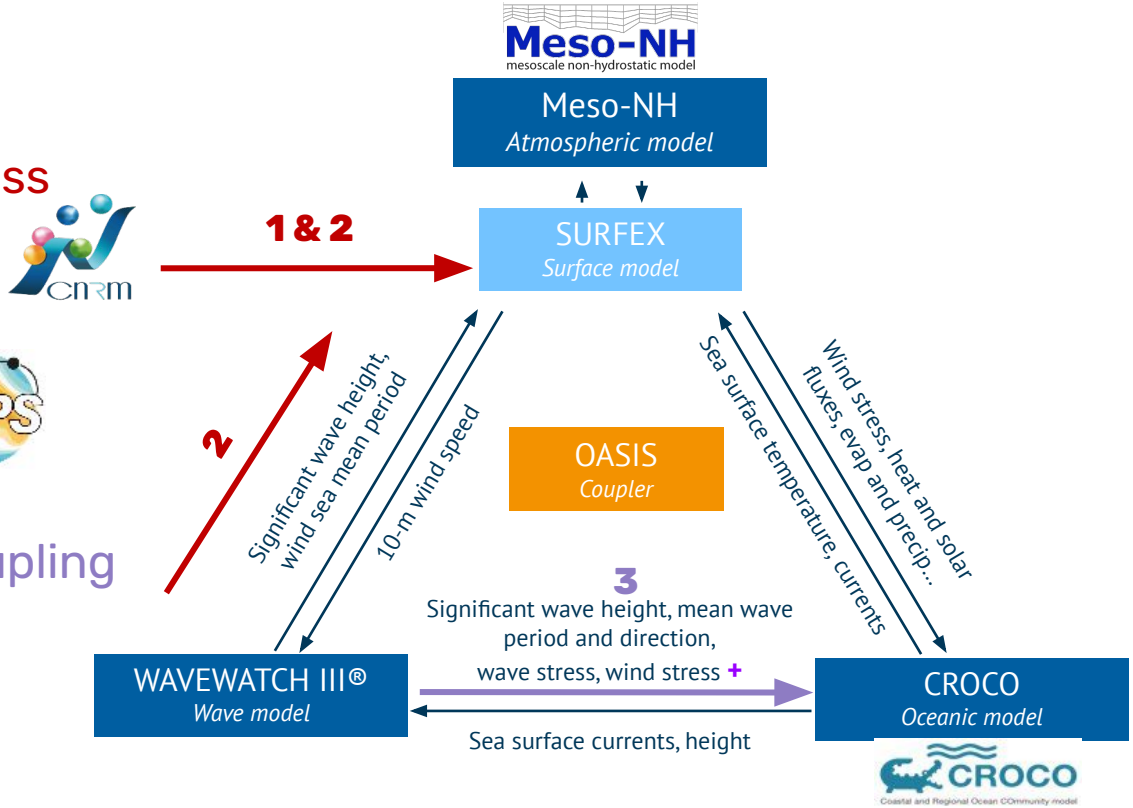
The French coupled model framework

Latest developments:

1. wave-age-dependent stress parameterisation
   (WASP, *Bouin et al. 2023*)
2. sea spray fluxes
   (*Brumer et al. in prep*)
3. extended wave-ocean coupling
   (*Porcile et al. 2023*)



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Numerical simulations

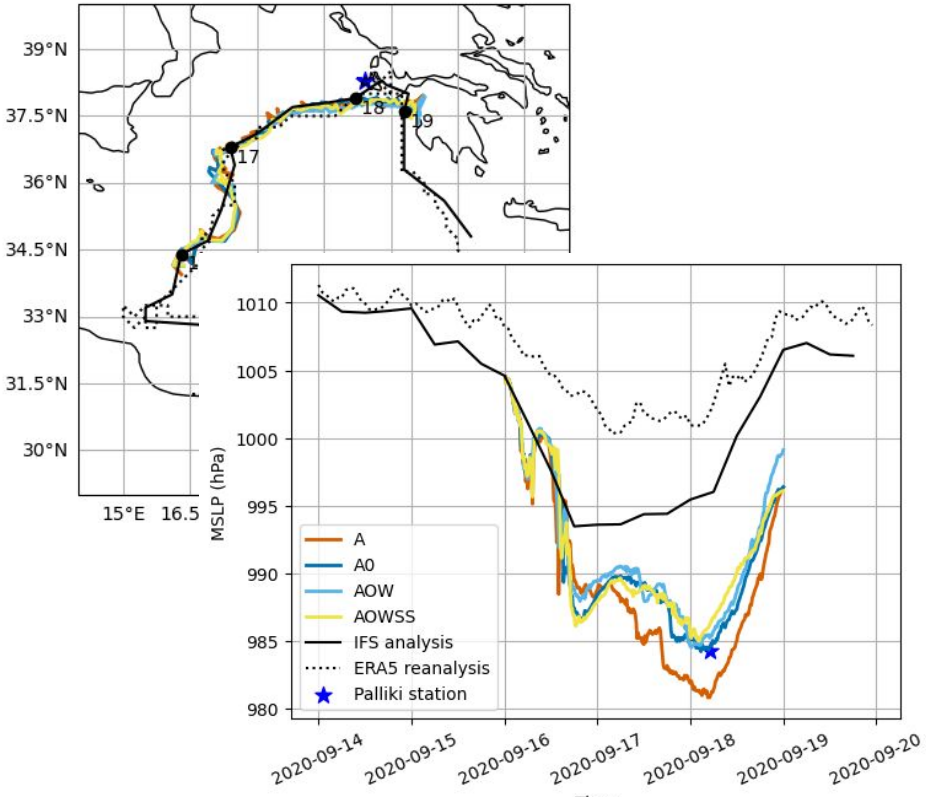
4 simulations @ 1.8 km resolution:

1. Atmosphere only
2. AO : atmosphere-ocean
3. AOW : atmosphere-ocean-waves
4. AOWSS : AOW with sea spray

→ Higher resolution leads to deeper low Our runs vs. ERA5/IFS

→ **Coupling decreases intensity closer to in situ observation**

→ Track minimally impacted by coupling and well represented in all simulations



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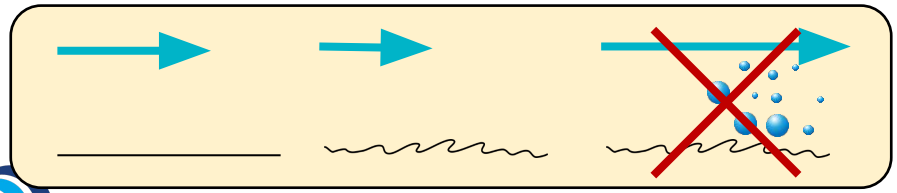
Coupling impacts on the 10-m winds

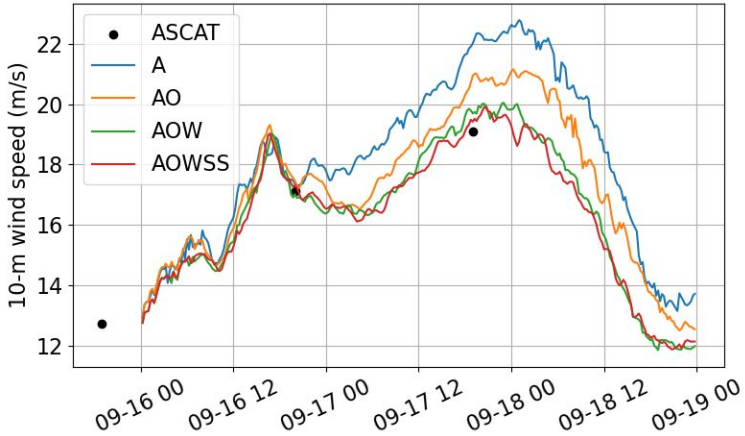
Wave coupling

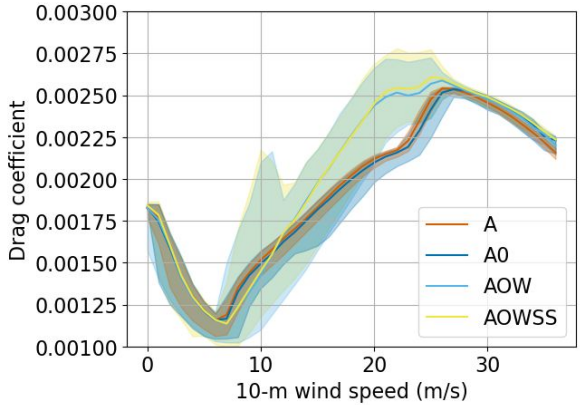
→ lowers the 10-m winds closer to scatterometer observations

→ increases the drag coefficient for winds between 10 and ~ 25 m/s (WASP design)

Sea spray has negligible impact on the drag but slightly decreases the intensity







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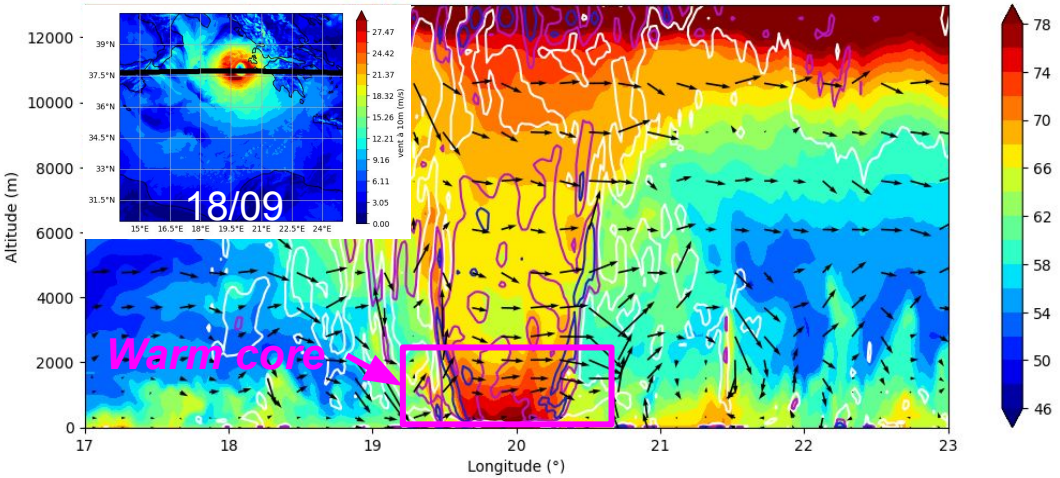
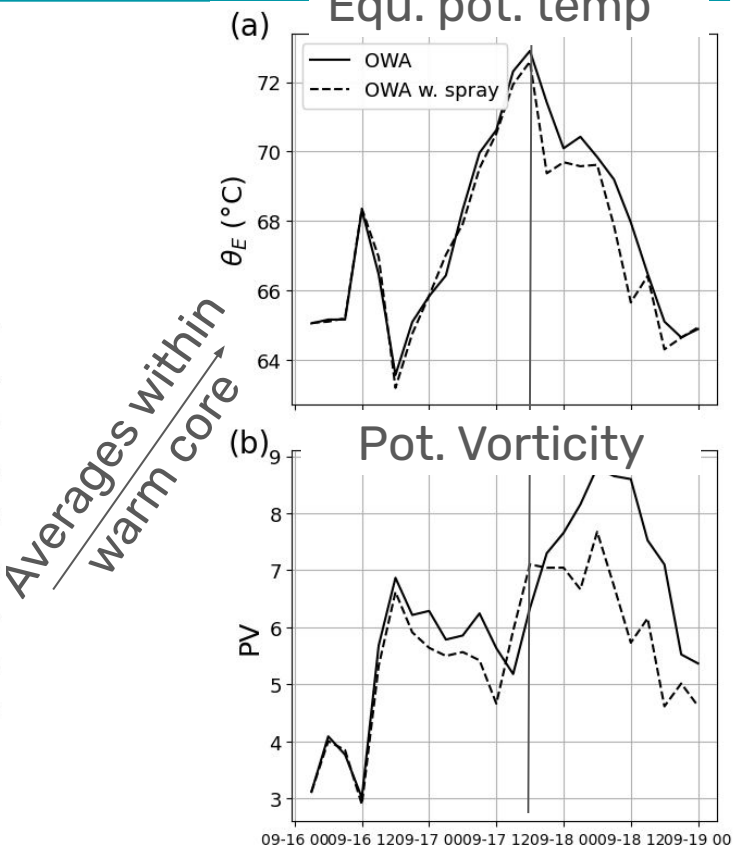
Impacts of sea spray

Sea spray cools the boundary layer

→ suppresses deep convection

→ weakens storm





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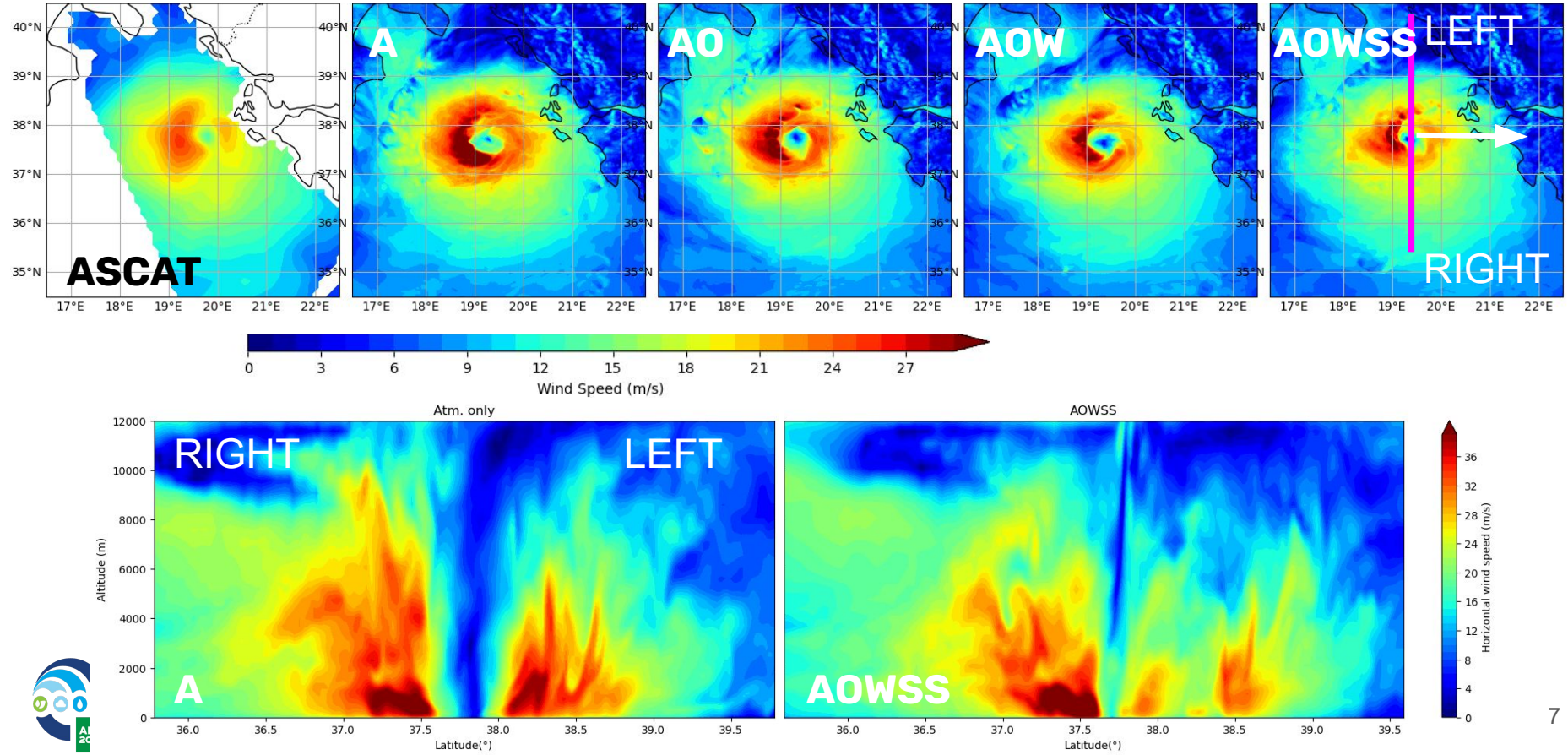
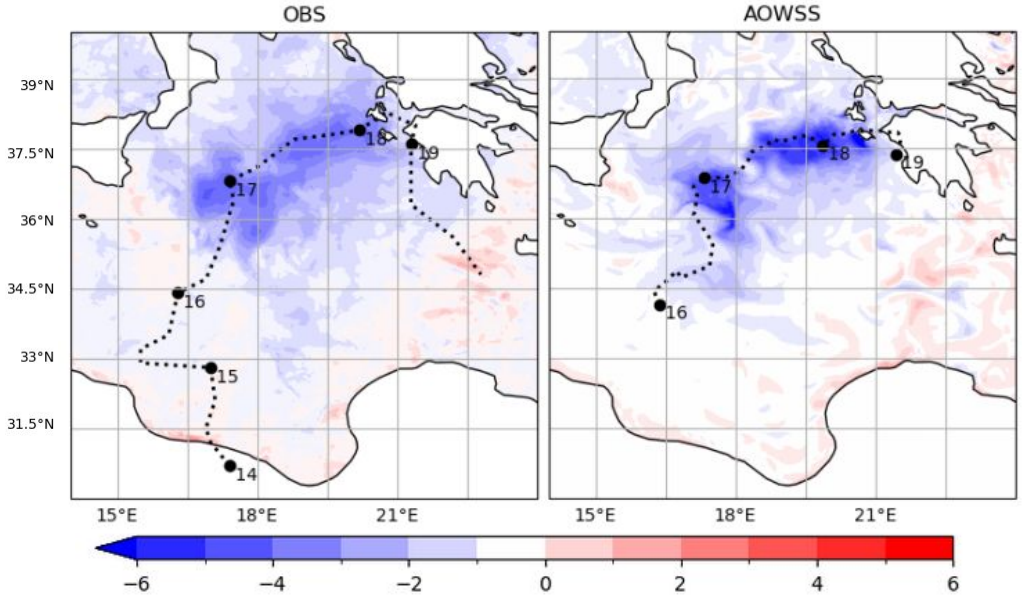
Coupling impacts on the 3D wind structure



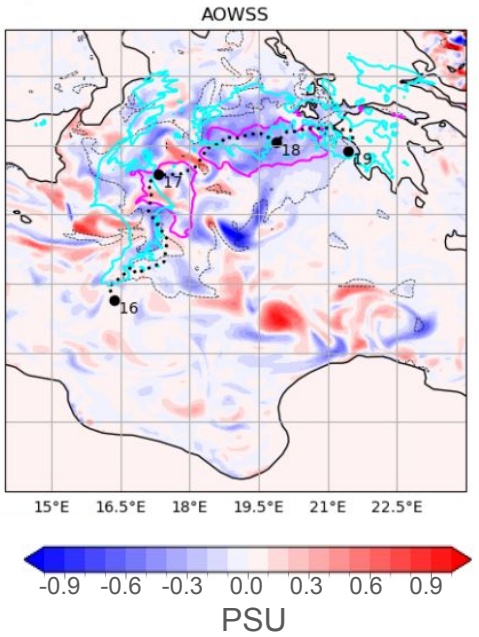
Cold wakes & Salinity

ΔSST



Strong cooling (ΔSST > 4°C)
along the path in 2 separate patches

ΔSSS



Varied salinity response

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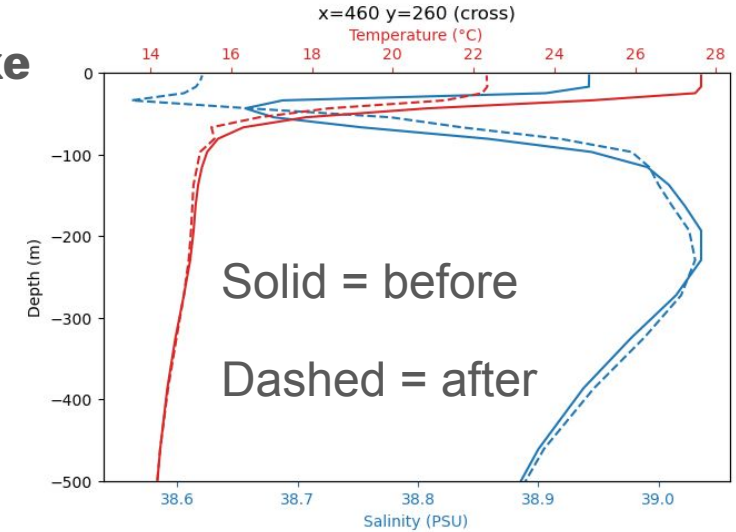
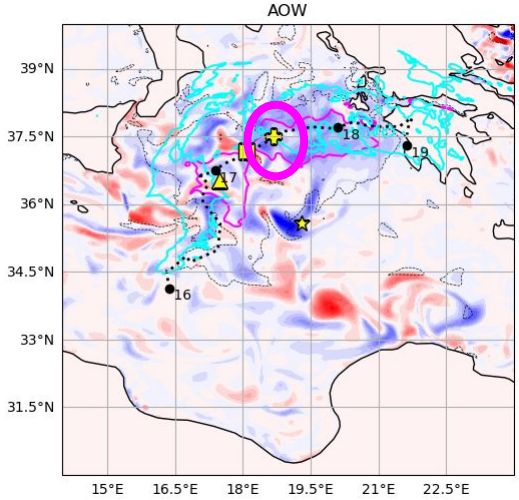
Ocean mixed layer processes

Profiles in 2nd cold wake

- Cooling & freshening at surface & depth
- 10 m deepening of MLD

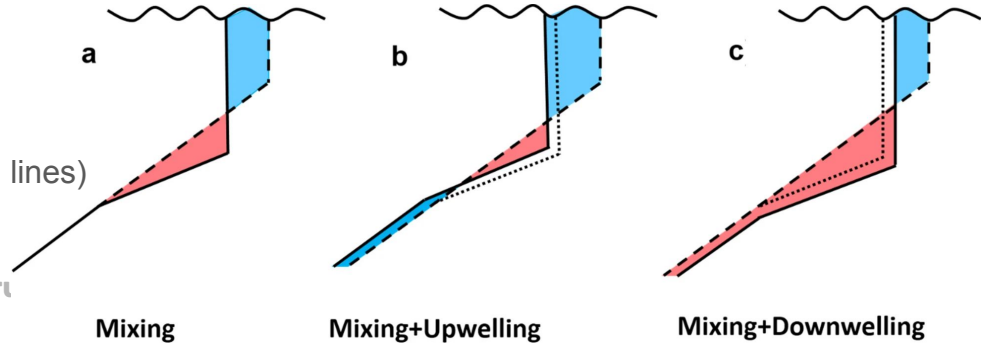
→ **upwelling** + mixing + rain





Matches conceptual model for TC wakes

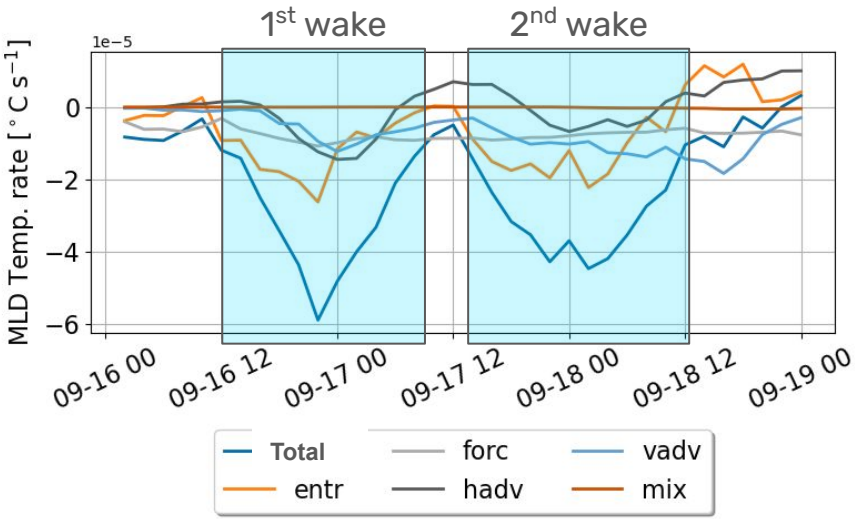
Temperature anomalies
before (dashed lines) and after (solid lines) mixing only (dotted lines)
Zhang et al. (2021)



Mixed layer budgets

Storm following averages with 1° radius

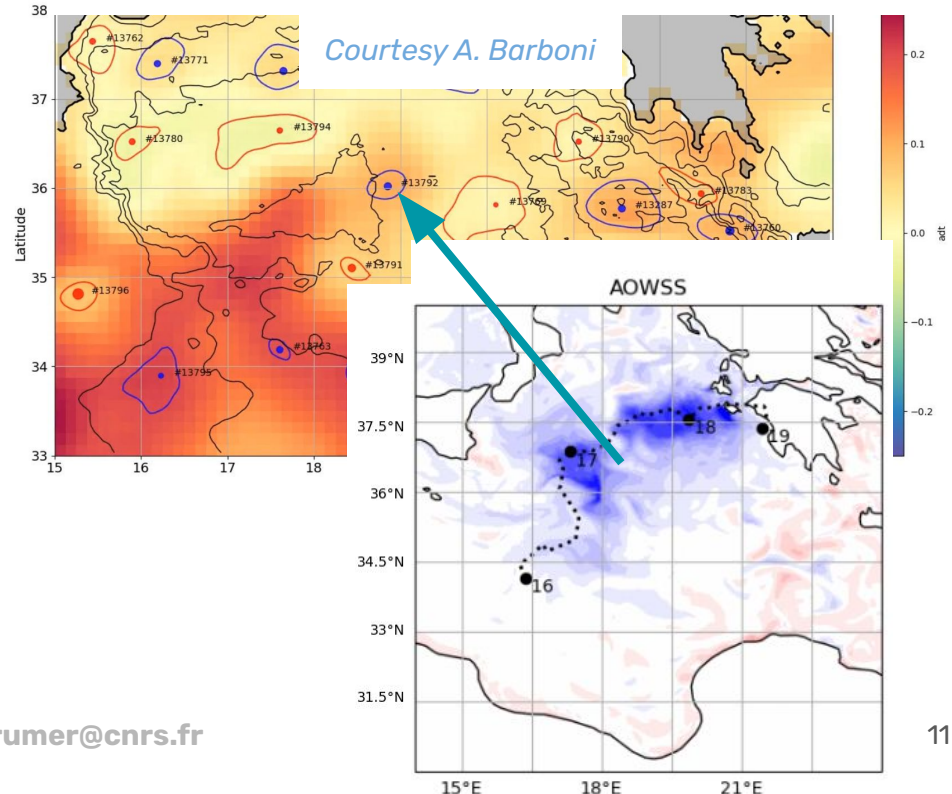
- 2 cold wakes
  - entrainement major contributor to signal
  - ~ constant forcing throughout
- In between
  - entrainment goes to zero
  - horizontal advection leads to warming



Wake-eddy interaction

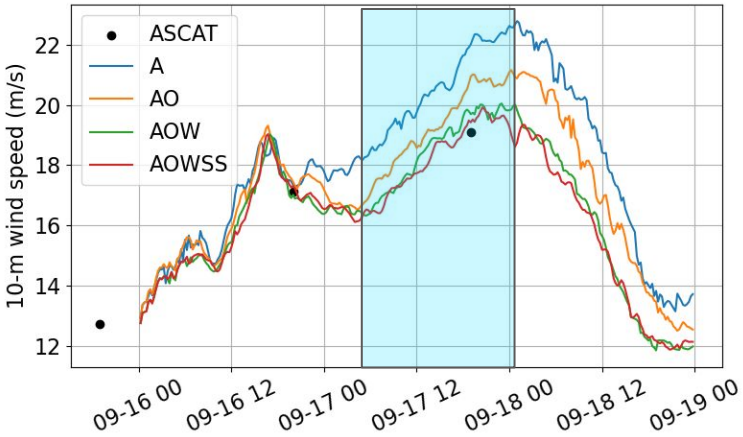
Warmcore eddy on the path could
- account for ‘break’ in cold wake

AMEDA eddies 2020-09-17
red = cyclones / blue = anticyclones



Wake-eddy interaction

Warmcore eddy on the path could
- account for ‘break’ in cold wake
- be responsible for the 2nd intensification



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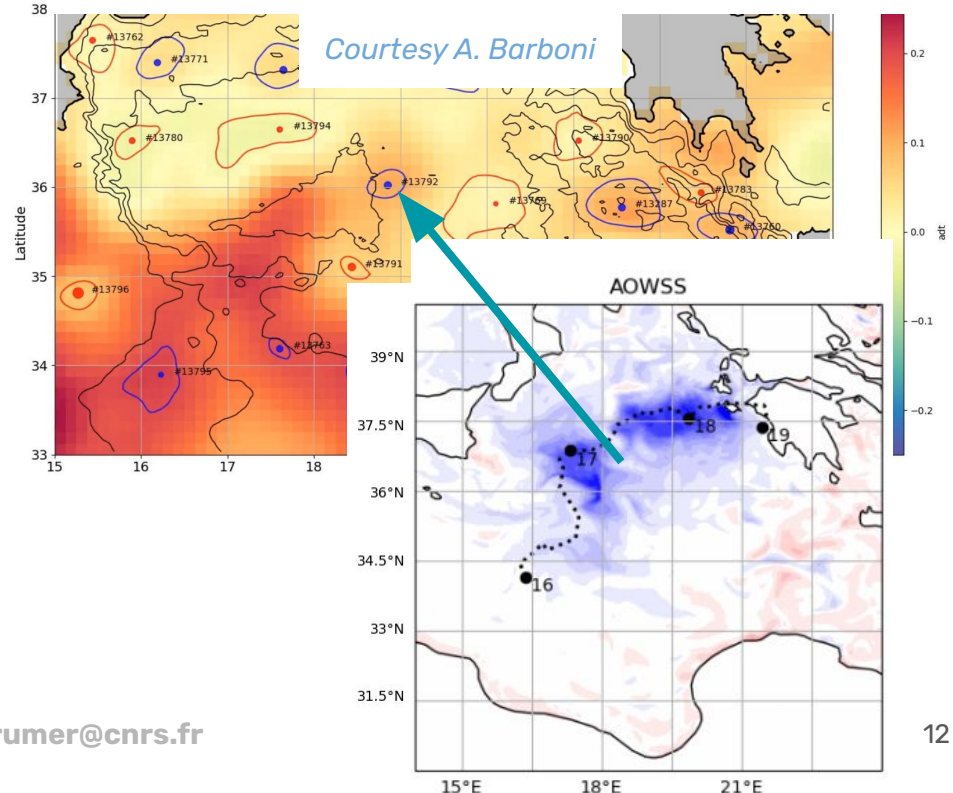

Conclusions & Perspectives

Ianos is a Mediterranean cyclone with ‘tropical-like’ characteristics in that it produces a **cold wake that negatively impacts its intensity**

km-scale coupled atmosphere-wave-ocean simulations of Medicane Ianos

1. Allowed good representation of the storm track & intensity & cold wake
2. Showed that waves & sea spray accentuate MABL asymmetry
3. Revealed how sea spray weakens storm due to boundary layer cooling
4. Suggests potential warmcore eddy - cyclone interactions

COUPLED MODELING IS NECESSARY FOR MEDICANES

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